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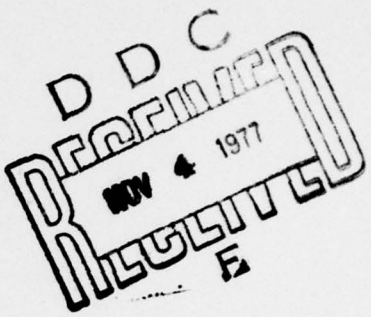


# SUCCESS PREDICTORS FOR STUDENTS TO ATTEND AFIT DEPARTMENT OF SYSTEMS MANAGEMENT MASTER'S DEGREE PROGRAMS

THESIS

Robert . Keith
Major USAF

AFIT/GSM/SM/77S-7

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Robert W. Keith
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## Preface

This research was performed to determine the characteristics which best predict success among potential Air Force Institute of Technology (AFIT) Department of Systems Management students. If the implementation of my suggestions does in fact reduce the chance that an accepted student will fail to attain his degree, my efforts will have been worthwhile, both for the Air Force and the prospective student.

In an effort to provide a useful document as opposed to an academic exercise, I have attempted to write this report in plain English to the maximum possible extent. However, the statistical techniques and results essential to the discussion are included.

I wish to express my gratitude to Dr. Michael Stahl for suggesting this study and providing his aid and encouragement, and to Dr. Charles McNichols for helping me overcome computer related problems. Additionally, I would like to thank Mr. Harold Lillie and Lieutenant Colonel Gerald Malicki of the AFIT Directorate of Admissions for freely providing the information without which this research would not have been possible.

Robert W. Keith

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## ABSTRACT

This research was conducted to investigate the prediction of success among Systems Management and Operations Research Master's degree students. A total population of 223 male United States Air Force (USAF) officers who attended AFIT from 1971 through 1976 was analyzed.

Graduate grade point average (GGPA) prediction was investigated using multivariate regression analysis, and success based on degree receipt or nonreceipt was examined through the application of the Automatic Interaction Detection algorithm and discriminant analysis. The predictor variables examined included not only ability and biographical data, but several surrogate measures of motivation toward degree achievement as well.

The results of the GGPA study confirmed the findings of previous researchers that students in different disciplines should not be combined for GGPA predictive purposes, and also indicated that the GGPA predictive power attainable is modest. Additionally, the use of GGPA as a criterion of academic success is of questionable value. Most significant was the finding that student selection criteria truncate from the population those persons who lack the ability to achieve a degree, and that the motivational measures were the best predictors of degree receipt.

# SUCCESS PREDICTORS FOR STUDENTS TO ATTEND AFIT DEPARTMENT OF SYSTEMS MANAGEMENT MASTER'S DEGREE PROGRAMS

## I. INTRODUCTION

The U.S. Air Force, like civilian industry, has a continuing requirement for managerial and technological employees who possess a deep and current understanding of the knowledge in their particular field. This requirement has led both industry and the Air Force to the conclusion that the sponsorship of Master's degree students is not only desirable, but essential to the success of the organization.

However, the decision to allow an officer to attend an Air Force Institute of Technology (AFIT) Master's degree program represents a large investment. His education is almost totally Government funded and includes not only school expenses, but the cost of his move to Wright-Patterson Air Force Base, Ohio and his normal salary for 15 or 18 months, depending on field of study, as well.

The program can prove costly to the degree candidate in other ways. Although there is frequently no overt stigma attached to failure to obtain the advanced degree, the student has lost the time he could have more effectively spent in improving his promotability in other ways (such as gaining added job experience).

Thus, the reduction of the number of degree nonrecipients would benefit both the Air Force and the individual student. Although only 10.3 percent of the candidates in the population investigated failed to obtain a Master's degree, it is felt that improvement is both possible and highly desirable.

The research reported on in this thesis was conducted to evaluate data which could be used to improve the predictability of student academic success in the AFIT School of Engineering Department of Systems Management. In this first chapter several background topics are discussed. The first is a report on the techniques used and results achieved from previous academic success prediction efforts. Second, a statement of the problem is presented. Next, a discussion of the current AFIT eligibility criteria is provided. Fourth, a statement of the hypothesis is made. Finally, the limitations imposed and assumptions made are addressed.

Because the use of the entire name for many terms prevalent in this thesis would prove cumbersome, a list of abbreviations is provided as Appendix A for the reader's convenience.

## Previous Prediction Attempts

It is difficult to read a journal dealing with education and not find at least one article pertaining to the prediction of academic success. This fact indicates the importance placed on the evaluation of existing and proposed advanced degree selection factors. The several techniques and results discussed in this section represent a cross-section of the state-of-the-art as it exists at the time of this writing.

The most commonly used criterion of academic success found in the literature is grade point average (GPA). Grade point average provides a continuous scale of accomplishment and can be used with many statistical techniques. The methods employed included bivariate correlation analysis, multivariate regression and correlation analysis, classification using the Wald statistic, and discriminant analysis. The applications of these methods using the GPA criterion will now be discussed.

The use of bivariate correlation for the prediction of graduate grade point average was reported by Wilson (1977) and by Lin and Humphreys (1977). Wilson's study, which was performed for AFIT, used GGPA as a criterion and undergraduate grade point average (UGPA) and Graduate Record Examination (GRE) verbal (V) and quantitative (Q) scores as predictors. Unexpectedly, GRE-V correlated higher than GRE-Q with GGPA for the Electrical Engineering group, while GRE-Q was the better predictor for those in Facilities Management. Additionally, while the correlation coefficient between GGPA and UGPA for Electrical Engineering students was .61 (N = 30), it was -.25 (N = 26) for Facilities Management majors (Wilson, 1977:4). This phenomenon led Wilson to state that significant differences can occur "...between admissions-related predictors and performance measures in one or more degree programs" (Wilson, 1977:A-1). Thacker and Williams (1974), in their article, also warned that "...the practice of combining departments for predictive purposes should not be employed" (Thacker and Williams, 1974:940), and influenced this writer to investigate the effect of systematically reducing the subject population into progressively more homogeneous subgroups. The methodology and results are discussed further in Chapters II and III.

The research performed by Lin and Humphreys also used correlations between UGPA and GGPA as well as between these and GRE and Law School Aptitude Test scores. Although their research was far more detailed than Wilson's and indicated that their predictors tend to deteriorate in utility over time (Lin and Humphreys, 1977:256), the use of bivariate correlation fails to consider the possibility of interaction between various predictors.

A far more powerful statistical tool for the investigation of several variables is multiple regression analysis, and this technique has been the most prevalent in the literature, especially when GGPA is used as the criterion.

Bean (1975) and Covert and Chansky (1975) used multiple regression and the most commonly used predictors (and advanced degree admission criteria), UGPA and GRE scores, in an attempt to predict GGPA. Bean also investigated Master's Comprehensive Examination scores and grades in individual required courses as criteria. Their "Results showed different predictability across the different subgroups" (Bean, 1975:947), and indicated "...the need for local validation of graduate admissions measures" (Covert and Chansky, 1975:963).

A research effort conducted by Federici and Schuerger (1974) centered on the use of multiple regression to predict GGPA and faculty ratings of students from UGPA, test scores, interview ratings, and biographical information. Additionally, factor analyses were performed to reduce the number of independent variables from 32 to 11 prior to the regression. Their study replicated several earlier investigations in that: (1) "modest but significant correlations with academic competency were realized, (2) the use of an interview and biographical information was supported in selecting for interpersonal skills, (3) ratings of recommendations failed to predict either graduate GPA or ratings of interpersonal skills" (Federici and Schueger, 1974:952).

Soetrisno (1975) and Anderson (1974) employed stepwise multiple regression to develop linear equations for the prediction of GPA at the Naval Postgraduate School and at the USAF Academy. The wide variety of

academic and biographic variables used showed a great deal of initiative, yet the incremental multiple correlation coefficients achieved demonstrated that one or two of the commonly used ability variables accounted for most of the variability in GPA.

Hunt (1977), in a primarily illustrative paper, proposed the use of the Wald statistic for the classification of a student as predicted to achieve above or below a specified GPA in junior and senior course work. As predictors Hunt used Scholastic Aptitude Test scores and freshman and sophomore cumulative GPA, and based his decision rule on cost minimization of a classification error. Although Hunt suggested a novel approach, the classification utility and easy accessibility of discriminant analysis programs (Nie, et al., 1975:434-467) make discriminant analysis more applicable to this type of research at present.

The only application of discriminant analysis to the prediction of GPA encountered by this writer was undertaken by Sexton and Goldman (1975). Their research involved predicting which of five college GPA categories a student would fall into using high school grades and number of classes in five groups (English, Math, Science, History, and Foreign language) as independent variables. The results achieved were that GPA "...was only related to high school grade averages," and "While the pattern of high school preparation is related to the choice of a college major, it is not related to college success" (Sexton and Goldman, 1975: 37).

Now that a discussion of the research conducted to predict GPA as an academic success criterion has been completed, a different measure of success will be considered. That measure is whether or not the degree

candidate did complete the requirements for a degree. As was mentioned earlier, GPA can be easily evaluated as a criterion with most statistical techniques, but is it actually the best measure of success? Can it be said that a degree candidate with excellent grades who does not graduate because he cannot satisfactorily complete his thesis work is a "success" based on GGPA, whereas the student with the lowest GGPA in his class who receives his degree is a "nonsuccess?" In reality the ultimate success criterion is the dichotomous "degree/no degree" variable, and although GGPA prediction was evaluated and will be discussed, the primary purpose of this research, as indicated initially, was to predict degree receipt. Several efforts at predicting advanced degree completion are now presented.

In an attempt to predict degree attainment among doctoral candidates, Nagi (1975) used bivariate correlation analysis with GRE and Miller Analogies Test (MAT) scores as predictor variables. Both correlation coefficients failed to reach statistical significance at the .05 level, and Nagi concluded that "...the GRE and MAT are not substantially valid predictors of program completion" (Nagi, 1975:472).

An interesting though simplistic approach to predicting the acquisition of advanced graduate and professional degrees was reported by Lewis (1974). As predictors Lewis classified BA graduates into four groups based on high or low academic aptitude (from Iowa Placement Test scores) and academic achievement (UGPA). He further broke down the groups based on sex. The percentage of BA graduates in the four ability-achievement groups for each sex completing advanced education were then calculated, and the differences between the percentages were tested for significance

using the $\chi^2$ statistic. A noteworthy finding was that the low aptitude/high achievement males were second only to those with high aptitude/high achievement, and were above the high ability/low achievement male group. A hypothesis for this phenomenon is discussed later in this chapter.

The final study discussed in this section involves the prediction of graduate degree receipt using the logistic quantal response model, and was reported by Pickens (1971). Using this model, Pickens estimated the functional relationship between the probability of achieving a Master's degree and the two GRE scores. Because he attempted to predict a 95 percent probability of success from a population containing 94 percent successes, Pickens' results were inconclusive. However, he did state that, based on the low GRE scores attained by several successes and the fact that the mean weighted score for failures was just 38 points lower than for successes, "...a reasonable policy would be to cease requiring applicants to submit GRE aptitude scores" (Pickens, 1971:38). Pickens' recommendation has not been widely accepted although other research results do tend to indicate that the GRE, at least by itself, is not a powerful success predictor.

Numerous criteria and techniques have been utilized in past attempts to predict academic success, and the results reported were used to stimulate thought concerning the methodology to be used in conducting this research. Having considered previous efforts, the remainder of this chapter will deal with topics pertaining directly to the research reported on in this thesis.

## Formal Problem Statement

This study was conducted to answer the following question: What data available to the AFIT Director of Admissions best predict success among candidates for Systems Management (SM) and Operations Research (OR)* Master's degrees?

## AFIT Eligibility Criteria

A Graduate Systems Management (GSM) or Graduate Operations Research (GOR) student, to be eligible (although not necessarily selected) for AFIT education, must meet three requirements:

(1) undergraduate cumulative GPA at least 2.5 on a 4.0 basis,

(2) minimum score of 500 on the Graduate Management Admission Test (GMAT) total or on both the GRE-V and GRE-Q,

(3) previous experience which indicates an ability to effectively learn and use the AFIT education for the good of the Air Force.

However, tradeoffs between these requirements are permitted. For example, a prospective student with a UGPA of less than 2.5 might be eligible if he had previously attained practical experience in his prospective field of study, or one with a low GRE-V score could overcome it with a high score on the GRE-Q. Cases are judged on an individual basis by the AFIT Director of Admissions (Malicki, 1977).

A detailed description of the USAF Advanced Academic Degree Management System is provided as Appendix B.

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*The GOR program was coded GSA (Graduate Systems Analysis) prior to 1975.

## Statement of the Hypothesis

Psychologists have known for many years that "...a person needs both ability and motivation to perform well." (Porter, Lawler, and Hackman, 1975:153). However, the selection criteria for most graduate programs (including those for AFIT) have traditionally dealt with the measurement of ability alone. The research performed for this thesis investigated not only ability measures, but also attempted to assess the predictive power of several "surrogate" motivational factors. These factors are discussed in detail in Chapter II.

For the above reason, the following hypothesis is made: predictors exist which can be used to aid in the selection of students to attend AFIT GSM or GOR Master's degree programs, and measures of both ability and motivation are predictors of success.

## Scope and Limitations

Due to the vast amount of data available and the time constraint imposed, only predictors for the selection of students for the AFIT Department of Systems Management were examined. However, certain predictors (especially motivational) could, with further research, prove applicable for the selection of students for other departments as well.

Additionally, no data were collected on GSM or GOR students who were scheduled to graduate prior to 1973 to minimize wartime distortion.

Chapter II provides a thorough description of the subject population.

## Assumptions

It is assumed that the ultimate criterion of success in an advanced academic program is degree receipt, and that cumulative GGPA is a secondary measurement.

## Summary and Overview

This first chapter has discussed background information considered pertinent to the research performed, and was intended to prepare the reader for the report to follow. Six topics were discussed:

(1) previous prediction attempts,

(2) formal problem statement,

(3) AFIT eligibility criteria,

(4) statement of the hypothesis,

(5) scope and limitations, and

(6) assumptions.

Three more chapters are included. In Chapter II the overall research methodology is discussed. Chapter III presents the results of the analysis. Finally, the conclusion and recommendations are made in Chapter IV.

## II. METHODOLOGY

In this chapter the methodology used to conduct the research is discussed in four parts. These parts consist of the composition of the population examined, the criterion variables, the predictor variables, and the specific analytical techniques utilized.

### Population

The population examined included all male USAF officers who began the GSM or GOR program in August 1971* or later and who either received a degree or were released from the program and did not receive a degree prior to April 1977 (the data collection month). Only three subjects, all civilian, were rejected. This resulted in a total population of 223 students in seven GSM (N = 138) and five GOR (N = 85) classes expected to graduate in 1973 through 1976. Part of the total population also included four students scheduled to graduate after April 1977 but who chose Self-Initiated Elimination (SIE) prior to April and thus became part of the data group. The population contains 23 persons (13 GSM and 10 GOR) who failed to obtain a degree for reasons which are provided in the next section. The data selected for evaluation were extracted from individual student records which are maintained at the AFIT Directorate of Admissions. These records contain the information available to AFIT for the determination of eligibility, a complete transcript of the student's AFIT grades, and basic biographical facts.

*The GOR program was 21 months in length at this time, and the GSM was 18 months long.

Criterion Variables

Two criteria of academic success were selected for the analysis. The secondary measure for the purposes of this thesis, GGPA, is discussed first, then degree receipt/nonreceipt, the primary criterion, is considered.

GGPA. This is the total cumulative AFIT grade point average achieved for all graded course work (including thesis) until graduation or release from the degree program on a 4.0 basis (4.0 = all A's). The seven SIE's (3 GSM, 4 GOR) were deleted from consideration using this criterion due to the questionable meaning of their GGPA's, but were considered as part of the "no degree" population.* For the remaining 216 cases, the mean GGPA was 3.44 with a standard deviation of .44.

It was originally planned to investigate GGPA without thesis grade as a criterion as well, but, because the bivariate correlation coefficient between GGPA and GGPA without thesis was .99plus, this effort would have proven redundant.

Degree Receipt/Nonreceipt. Prediction of this dichotomous criterion variable was the primary purpose of this research. Degree receipt is defined as meeting the AFIT requirements for graduation within five years after the scheduled graduation of the class section (Air Force Institute of Technology, 1976:30) or by the data collection month (April 1977), whichever occurs first. Degree nonreceipt is considered to be noncompletion of the requirements in the same time frame. There were varied reasons for noncompletion of the degree requirements. For the population investigated

*Although the identification of factors which might indicate which SIE candidates would voluntarily join the "no degree" population is of vital interest, it is doubtful that most of their GGPA's would indicate performance had they not reached an SIE decision.

these reasons included: (1) academic deficiency, (2) incomplete or unacceptable thesis work, (3) lack of academic integrity (one student), and (4) SIE. It is interesting to note that, except for two students who accomplished their degree requirements shortly after the scheduled class graduation, none of the candidates who failed to receive a degree on time completed the degree requirements later. However, two degree nonrecipients are presently known to be working toward requirement completion.

## Predictor Variables

The selected predictors of success based on the above criteria consisted of 14 independent variables. These variables were chosen so as to provide a varied base of academic and biographic factors and yet be readily available to AFIT Directorate of Admissions personnel. Each of the predictor variables is discussed in detail below.

Undergraduate GPA. UGPA is the most commonly used success predictor for graduate school admission. It provides a measure of the past academic achievement (a function of both ability and motivation as was discussed in Chapter I) of the prospective student. All UGPA's were computed on a 4.0 maximum basis. The total population (N = 223) has a mean ($\bar{x}$) UGPA of 2.96 with a standard deviation (s) of .34.

Age at AFIT Entry. For age of the student in years at the start of his AFIT education, the population $\bar{x}$ = 30.31 and s = 3.63.

Time Since Undergraduate Degree Receipt. This is the number of years since receipt of the Bachelor's degree and was selected to investigate the possible influence of academic "staleness." It was expected that this variable would be very highly correlated with age and the bivariate

correlation coefficient between the two (.740) was significant although not as high as anticipated. Total population $\bar{x}$ = 7.04, s = 3.21.

National Military Academy. This dichotomous predictor represents whether or not a student's undergraduate degree was granted by the U.S. Air Force Academy, U.S. Naval Academy, or U.S. Military Academy. It was selected to investigate the relationship between undergraduate education in a rigid environment and graduate school performance. Of the total population, 38.6 percent attended a military academy.

Undergraduate Degree not in Engineering, Math, or a Physical Science. Because both the GSM and GOR curricula require the use of analytic geometry, matrix manipulation, differentiation, and integration, this variable was selected to measure quantitative background. The number of students not possessing one of these degrees is 21.1 percent of the total.

Marital Status. This variable is a dichotomy only and is defined as married or single at the time of AFIT entry. No attempt was made to investigate further breakouts such as single but divorced or married but separated. The single students constituted 14.4 percent of the total population.

Volunteer for AFIT. Unlike students at civilian universities, AFIT students need not necessarily apply for admission. Prospective AFIT Master's degree candidates can, of course, apply. The application (volunteer) process involves the actual preparation of a formal request for advanced education and is accompanied by the usual documentation necessary for acceptance into most civilian Master's degree programs (college transcript, biographical data, etc.). Additionally, the prospective student must complete the GRE or GMAT before his application is considered.

As an alternative, the student may be selected for AFIT education without applying. These students are termed "centrally identified" (non-volunteer). A description of this selection process is provided in Appendix B. The nonvolunteers did not actively seek out the opportunity to achieve an advanced degree as did the volunteers. For this reason volunteer status is used as a surrogate measure of the student's motivation toward the attainment of the degree. The population includes 46.2 percent volunteers.

Aeronautical Rating. This variable, like the preceeding four, is dichotomous. No distinction is made between types of rating (pilot or navigator) for this study. The total population contains 60.1 percent USAF rated officers.

GRE Scores. The GRE, like UGPA, is a widely used instrument for determining the acceptability of graduate education applicants, although AFIT allows the student to complete the GMAT as an alternative (Air Force Institute of Technology, 1976:6). Three different GRE scores were gathered. The GRE verbal and quantitative scores were recorded on a percentile basis to allow combination and comparison with the GMAT scores. The percentile standing was selected because GMAT and GRE scores are scaled differently. Although percentile ranks for a given score depend on when the test was taken, "Total scaled scores are directly comparable across years." (Educational Testing Service, 1975:13). However, the scaled scores were converted to percentiles using a single conversion chart (candidates tested from October 1971 through September 1974) thus making the percentile ranks obtained also directly comparable.

A GRE total (T) score was calculated by adding the GRE-V and GRE-Q scores. This treatment was necessary because there is no total score

provided for the GRE, yet an overall single figure was desired for the analysis. Additionally, summing the two scores provides a means of investigating the tradeoff policy (discussed in Chapter I under AFIT Eligibility Criteria) used by AFIT Admissions. To illustrate, a GRE-V of 450 and GRE-Q of 550 yields a total of 1000, the same total as would be obtained if 500 were scored on both parts.

The means and standard deviations for all those taking the GRE (N = 140) are provided in Table I.

TABLE I

GRE Means and Standard Deviations

| | $\bar{x}$ | s |
|---|---|---|
| GRE-V (percentile) | 63.81 | 20.55 |
| GRE-Q (percentile) | 85.56 | 12.82 |
| GRE-T (points) | 1261.21 | 113.88 |

GMAT Scores. Entitled the Admission Test for Graduate Study in Business (ATGSB) prior to 1976, the GMAT is another frequently used instrument for graduate school student selection. Because the GMAT "...scores are related to the same reference group rather than to each other, it makes no difference when or where you are tested." (Educational Testing Service, 1976:13). Therefore, the GMAT-V and GMAT-Q scores were converted to percentiles in a manner identical to that used for the GRE scores and employing a conversion table based on 1971-1974 test results. Because a GMAT total score is also provided this value was recorded directly.

Table II contains the means and standard deviations for those students who took the GMAT (N = 102).

TABLE II

GMAT Means and Standard Deviations

| | $\bar{X}$ | s |
|---|---|---|
| GMAT-V (percentile) | 72.40 | 20.11 |
| GMAT-Q (percentile) | 75.53 | 18.65 |
| GMAT-T (points) | 570.88 | 73.60 |

Having discussed the population composition and variables selected for this study, a presentation of the techniques used in the analysis of the data collected is now given.

Specific Analytical Techniques

Predictor evaluation using the two selected criteria, GGPA and degree receipt/nonreceipt, was conducted by applying three multivariate data analysis techniques. GGPA, which provides a continuum of performance measure between 0.00 and 4.00, was investigated using multiple regression analysis. Evaluation of predictors for the dichotomous degree receipt/nonreceipt criterion was done using a combination of the Automatic Interaction Detection (AID) algorithm and discriminant analysis, two techniques well suited for the analysis of dichotomies.

The remainder of this chapter considers the specific analytical techniques used in the research. First, GGPA prediction is discussed and includes a description of the statistical technique employed as well as a review of the way that technique was applied. The section concludes with a synopsis of the degree receipt/nonreceipt criterion analysis and is organized similarly to the GGPA discussion.

GGPA Prediction. As was mentioned in Chapter I, regression analysis has been widely used in previous attempts to predict GGPA, but the efforts have not been highly successful. Further, past researchers (Wilson, 1977, and Thacker and Williams, 1974) warned against the practice of combining nonhomogeneous groups for predictive purposes. For this reason the intent of this portion of the study is to use multiple regression analysis to investigate the effect of progressively increasing the homogeneity of subject groups on GGPA predictive ability.

Bivariate regression analysis is a technique used for examining the connection between two variables by mathematically fitting a smooth trend line to the relationship between the variables. "Hence, the idea behind regression is that all observations of a variable are best explained by this fitted line, which is simply the calculated best fit of a trend line to the relationship between two sets of measurements..." (Heenan and Addleman, 1976:46). Multiple regression extends this idea to the case of one criterion and multiple predictor variables. A detailed treatment of multiple regression analysis is provided in a widely used text by Draper and Smith (1966).

For the research the stepwise multiple regression analysis subprogram contained in the Statistical Package for the Social Sciences (SPSS) was used (Nie, et al., 1975:320-367). In stepwise solution the independent variables are entered into the regression equation one by one and only if they meet pre-established statistical criteria, or are deleted if they no longer meet similar or other criteria (Nie, et al., 1975:345). An inclusion F ratio (Nie, et al., 1975:346) of 3.0 was selected so as to be slightly below 3.92, that value which provides a .05 significance level

for a fairly large sample and one independent variable (Nie, et al., 1975:339, and Freund, 1971:439).

The analysis involved the performance of five multiple regression computer runs. The first four runs considered three sets of progressively more homogeneous student groups. The fifth was conducted primarily to investigate the substitutability of one test for the other by examining a group who took both. Each of the five computer runs is described below.

(1) Total Population. This group (N = 216) includes all those students selected for the study less the seven SIE's. The GRE and GMAT scores were deleted from consideration as predictors to avoid the necessity of assigning a score of zero to a student who did not take a given test.

(2) All Students Who Took at Least One Entry Test. Selection of this particular group of 189 was performed to allow inclusion of test scores as predictors. The verbal and quantitative GRE or GMAT percentiles were used directly and coded TEST-V and TEST-Q if only one test was taken. If both tests were taken, the scores on each were averaged on the assumption that the tests are interchangeable as predictors (as AFIT Admissions practices). A total TEST score was calculated by adding the TEST-V and TEST-Q scores.

(3) All GSM Students Who Took a Test. This further breakout of the above population was performed to remove the effect of mixing students from different courses

of study and resulted in 135 students. TEST scores were used as predictors and were determined as described in the preceeding paragraph.

(4) All GOR Students Who Took a Test. This group was selected for the identical reason as was the GSM sample described immediately before, and contains 81 persons.

(5) All Students Who Took Both Tests. As was mentioned earlier, this group was selected to investigate the correlation between GMAT and GRE scores, and if they are not good substitutes, to find out which of the two best predicts GGPA. Surprisingly, 50 of the 216 total GGPA prediction population (23%) took both the GRE and GMAT.

The analytical techniques used to examine GGPA prediction have been discussed, and the results are presented in Chapter III. The methods used in predicting the primary academic success criterion, degree receipt or nonreceipt, are now examined.

Degree Receipt/Nonreceipt Prediction. For reasons given earlier in this chapter during the discussion of the criterion variables, this analysis was begun using the total collected sample of 223 students of which 23 were degree nonrecipients. Two distinct but interrelated analyses were performed. First, the Automatic Interaction Detection (AID) algorithm was used to look at the predictor values which were most characteristic of each of the two groups (degree or no degree) and to provide clues for the creation of new predictor variables. Then, discriminant analysis was applied to verify and further evaluate the AID results.

The AID algorithm "...is a heuristic approach to searching the raw data for structure and is purely a mechanization of the procedure a researcher might go through manually in hypothesizing a model." (Gooch, 1972:66). The computer program sequentially divides the set of data into subsets based on that split which causes the greatest reduction in the unexplained variability, and uses one-way analysis of variance over every possible predictor split. The computer output provides a series of splits and a set of subgroups best explaining the criterion variability (Gooch, 1972:63). A useful feature of AID is that a graphical display of the splitting process is provided in the form of an AID-Tree which "...allows visualization of the inherent structure in the data" (Gooch, 1972:63,66). A detailed description of the AID algorithm is provided by the developers, Sonquist and Morgan (1970).

For the AID computer run the maximum number of final groups allowed was set at 15, and five was selected as the smallest number of cases per subgroup. Eleven variables were chosen for inclusion in the analysis. The criterion used was degree receipt/nonreceipt. Six dichotomous predictor variables were investigated:

(1) course of study (GSM or GOR),

(2) did/did not attend a national military academy,

(3) undergraduate degree was/was not in engineering, mathematics, or a physical science,

(4) married/single,

(5) volunteer/nonvolunteer for AFIT, and

(6) aeronautically rated/nonrated.

Additionally, four continuous variables were used, and each was subdivided into five intervals as indicated in Table III. The subdivision

of UGPA was accomplished so as to provide one interval for students who did not achieve an undergraduate 2.50 (AFIT eligibility criterion) and four other intervals representing various levels of achievement. The age variable groups include subjects ranging from "young" to "old" relative to most AFIT GSM and GOR students (62.8% of the sample were between 27 and 32 when they entered). The test score intervals were selected to provide one for students not taking the test, one for those who took it but did not achieve the AFIT eligibility criterion score, one for students achieving very high scores, and two representing moderately high scores.

TABLE III

AID Continuous Predictor Variable Intervals

| Interval | Variable | | | |
|---|---|---|---|---|
| | UGPA | Age Entering AFIT | GRE-Total | GMAT-Total |
| 1 | 0-2.50 | 0-26 | 0(no test) | 0(no test) |
| 2 | 2.51-2.75 | 27-28 | 1-1000 | 1-500 |
| 3 | 2.76-2.95 | 29-30 | 1001-1200 | 501-550 |
| 4 | 2.96-3.15 | 31-32 | 1201-1350 | 551-625 |
| 5 | 3.16-4.00 | 33+ | 1351+ | 626+ |

After interpretation of the AID results was completed, investigation through the use of discriminant analysis was begun, and included a study of two different samples for reasons which are discussed later in this section.

Discriminant analysis is a statistical technqiue which

> "...tries to define a functional relationship for assigning individuals...to various groups. In other words, it attempts to classify an

> observation into one of several a priori groupings dependent upon the observation's individual characteristics." (Heenan and Addleman, 1976:46).

This characteristic makes it ideally suited for the dichotomous criterion and type of sample investigated for this thesis. A thorough treatise covering discriminant analysis can be found in the description of SPSS (Nie, et al., 1975:434-367).

The study consisted, first, of an evaluation of the total population of 223. Stepwise discriminant analysis using the maximum Mahalonobis distance criterion was employed (Nie, et al., 1975:447). Additionally, the F ratio for entry into the analysis was set at 3.0 (Nie, et al., 1975: 453-454), and a Bayesian adjustment was made to the group membership probabilities by inserting the prior knowledge of the population distribution of cases based on group size (Nie, et al., 1975:455-456). A run was also made with all the above criteria except that the probability of membership in either group was made equal.

The predictor variables used in the analysis were those determined from the AID investigation to be the most important, and included several newly created variables. The actual predictors employed are discussed in Chapter III when the results of the AID analysis are presented.

The discriminant analysis was taken one step beyond the examination of the total population due to a situation which cannot be ignored. Because the total population was made up of 89.7 percent "successes," it is not clear whether the discriminant weights based on the real data lead to high correct classification rates because of great inherent accuracy, or due to the possibility that they would classify almost all subjects as "successes."

In an effort to circumvent this possibility, one final discriminant analysis run was performed. All criteria (F ratio, etc.) were maintained constant. However, a new data group was created by using all 23 degree nonreceipients and randomly selecting an equal number from among those who did receive a degree. This new sample of 46 students was then subjected to computer evaluation, and the results obtained were compared to those for the entire student population. The results are presented in Chapter III.

Summary

This chapter has provided the reader with a description of the methodology used in conducting the research. Specifically, four topics were discussed:

(1) the population examined,

(2) the criterion variables employed,

(3) the predictor variables evaluated, and

(4) the specific analytic techniques used to predict GGPA and degree receipt/nonreceipt.

In Chapter III the results obtained are presented.

# III. RESULTS

This chapter provides the results and interpretations of the data analyses. The presentation is in three parts. First, GGPA prediction using multivariate regression analysis is discussed. Second, the use of AID for predicting degree receipt or nonreceipt is examined. Finally, the results of the degree receipt/nonreceipt investigation using discriminant analysis are provided.

## GGPA Prediction With Multivariate Regression Analysis

As was stated in Chapter II, one purpose of this portion of the analysis is to investigate the effect of increasing the homogeneity of the population on the predictive power attainable. Three levels of groups were investigated, and are summarized in Figure 1.

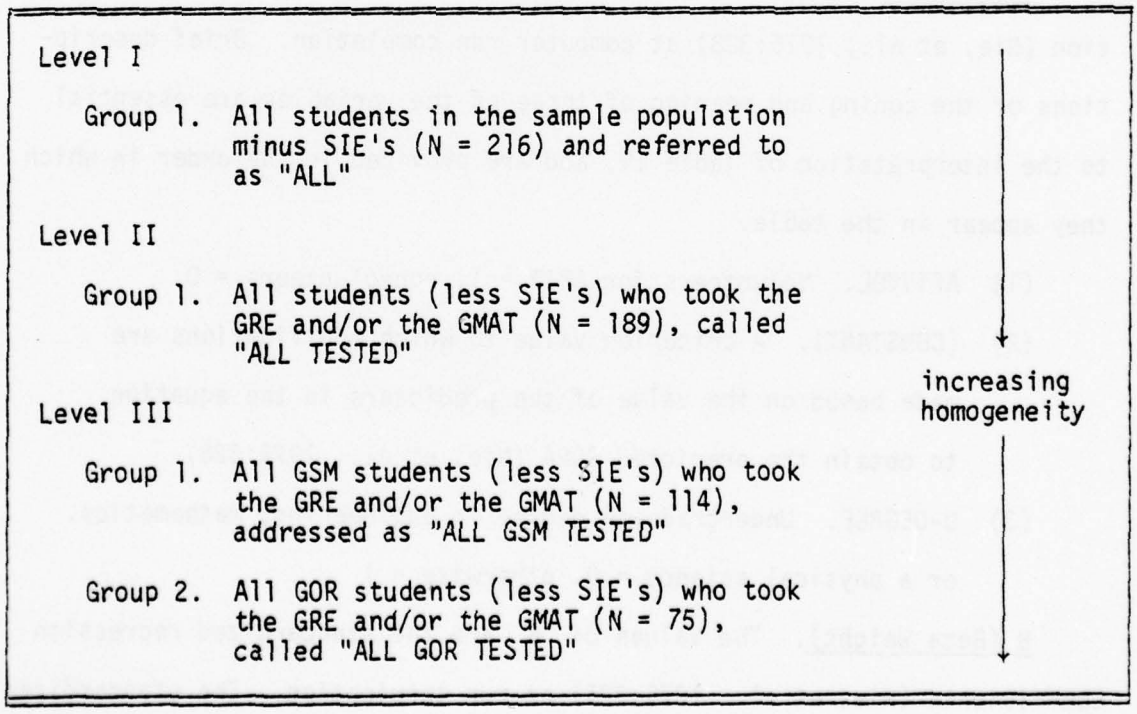


Figure 1. GGPA Prediction Homogeneity Levels

For the total group, eight predictors were utilized for the regression: (1) UGPA, (2) age, (3) time since receipt of undergraduate degree, (4) attended a military or civilian undergraduate institution, (5) undergraduate degree is or is not in engineering, mathematics, or a physical science, (6) single or married, (7) AFIT volunteer or nonvolunteer, and (8) aeronautically rated or nonrated. The remaining three regressions were run using the previous eight predictors and three others: (9) GRE and/or GMAT verbal percentile score (TEST-V), (10) GRE and/or GMAT quantitative percentile score (TEST-Q), and (11) the sum of the TEST-V and TEST-Q scores (TEST-T).

The results of the computer runs are presented in Table IV, and the bivariate correlation matrices are provided in Appendix C. The "Level" and "Group" columns in the table are as defined in Figure 1. Each of the remaining eight column meanings are described below.

Predictors. These are the variables present in the regression equation (Nie, et al., 1975:328) at computer run completion. Brief descriptions of the coding and meaning of three of the variables are essential to the interpretation of Table IV, and are provided in the order in which they appear in the table.

(1) AFITVOL. Volunteers for AFIT = 1, nonvolunteers = 0

(2) (CONSTANT). A criterion value to which modifications are made based on the value of the predictors in the equation to obtain the predicted GGPA (Nie, et al., 1975:328)

(3) U-DEGREE. Undergraduate degree in engineering, mathematics, or a physical science = 0, otherwise = 1

B (Beta Weight). The values of B are the standardized regression coefficients (Nie, et al., 1975:325) at run termination. The standardized

TABLE IV

GGPA Prediction Regression Results

| Level | Group | Predictors | B | F | Signifi-cance | Mult. R | Mult. $R^2$ (%) | Overall F | Signifi-cance |
|---|---|---|---|---|---|---|---|---|---|
| I | ALL (N = 216) | UGPA | .165 | 6.06 | .015 | .170 | 2.9 | 6.38 | .012 |
| | | AFITVOL | .140 | 4.37 | .038 | .220 | 4.8 | 5.43 | .005 |
| | | (CONSTANT) | 2.752 | 114.97 | .000 | | | | |
| II | ALL TESTED (N = 189) | TEST-T | .230 | 10.72 | .001 | .234 | 5.5 | 10.80 | .001 |
| | | UGPA | .162 | 5.36 | .022 | .280 | 7.8 | 7.89 | .001 |
| | | U-DEGREE | -.151 | 4.66 | .032 | .318 | 10.1 | 6.91 | .000 |
| | | (CONSTANT) | 2.293 | 54.68 | .000 | | | | |
| III | ALL GSM TESTED (N = 114) | TEST-T | .279 | 10.14 | .002 | .298 | 8.9 | 10.95 | .001 |
| | | UGPA | .249 | 8.08 | .005 | .388 | 15.1 | 9.86 | .000 |
| | | (CONSTANT) | 1.692 | 16.87 | .000 | | | | |
| III | ALL GOR TESTED (N = 75) | AFITVOL | .247 | 5.01 | .028 | .275 | 7.5 | 5.96 | .017 |
| | | U-DEGREE | -.239 | 4.61 | .034 | .363 | 13.2 | 5.47 | .006 |
| | | (CONSTANT) | 3.422 | 2285.39 | .000 | | | | |

values are used to enable the reader to determine the relative contribution of each variable to GGPA prediction keeping in mind that a B with a minus value indicates a negative relationship. The CONSTANT value is listed in this column for convenience.

F and Significance. The F ratio enables the determination of the significance level at which the regression coefficient of a given independent variable could be equal to zero (Nie, et al., 1975:336), and pertains to the value of B at run termination. No significance level of greater than .05 was accepted.

Multiple R and $R^2$. The value of R is the multiple correlation coefficient as each variable is added to the equation (Nie, et al., 1975: 331). The final R given is that obtained with all the variable present. The $R^2$ value is also provided because it enables straightforward interpretation of the percent of variation in the criterion explained by the predictors (Nie, et al., 1975:331).

Overall F and Significance. These values are interpreted the same as the F and significance previously discussed except that they do "...not indicate which specific B values are nonzero," (Nie, et al., 1975:336) and pertain to the overall values as each predictor enters the equation.

From Table IV it can be seen that the trend in the values of multiple R and $R^2$ is toward progressively better predictive power as sample homogeneity is increased. It could be argued that the increases in R are small, and this is conceded. However, it must be remembered that the GSM and GOR curricula are relatively similar, and it is suspected that much greater differences would be apparent if students in, for example, GSM and Electrical Engineering courses were combined and then separated for predictive purposes.

Several other observations from the table are worth consideration. First, UGPA is the most often included predictor of GGPA. Second, U-DEGREE, when present, is negatively correlated with GGPA. Finally, the multiple correlation coefficients obtained using a .05 significance requirement are modest, and indicate the difficulty of GGPA prediction and desirability of employing a more predictable success criterion.

It was mentioned earlier that a comparison of the GRE and GMAT as predictors of GGPA was also undertaken. The final portion of this section discusses the evaluation. Because only 50 students (13 GOR, 37 GSM) took both the GRE and GMAT, and because AFIT Admissions allows the submission of either test, the students from both disciplines were combined for this investigation.

Table V provides the bivariate correlation coefficients between the GRE and GMAT-V, GMAT-Q, and GMAT-T scores. It is apparent that the tests do not measure identical abilities, nor are they claimed to (Educational Testing Service, 1975:9, and 1976:4).

TABLE V

GRE and GMAT Bivariate Correlations

| | GRE-V | GRE-Q | GRE-T |
|---|---|---|---|
| GMAT-V | .783 | | |
| GMAT-Q | | .593 | |
| GMAT-T | | | .826 |

In an effort to determine the best test score for GGPA prediction, a final regression was run using 13 independent variables: UGPA, Age,

military academy (yes/no), undergraduate degree in engineering, mathematics, or a physical science (yes/no), marital status, volunteer status, aeronautically rated or nonrated, and the three GRE and GMAT scores. The results are given in Table VI, and the correlation matrix is in Appendix C.

TABLE VI

Test Score Regression Results

| Predictor | B | F | Significance | R | $R^2$(%) |
|---|---|---|---|---|---|
| GMAT-Q | .437 | 11.32 | .002 | .437 | 19.1 |
| (CONSTANT) | 2.383 | 58.52 | .000 | | |

For this group the best GGPA predictor is GMAT-Q. This result is not surprising in that both the GOR and GSM curricula are quantitative in nature and managerially oriented. It is surprising that GMAT-Q was the only variable to enter the equation using a .05 significance requirement, and that 19.1 percent of the variation is GGPA is explained by GMAT-Q alone.

GGPA prediction using multivariate regression analysis has been discussed. Now graduate school success using the degree receipt/nonreceipt criterion is considered, and begins with the results of the Automatic Interaction Detection (AID) analysis.

Degree Receipt/Nonreceipt Prediction with AID

It was stated in Chapter II that AID was not used as an end in itself but as a means of evaluating the structure of the data and creating new predictor variables for the discriminant analysis. This approach was used because, "While AID can identify potential relationships, its use is questionable on the matter of statistical significance." (Heenan and Addleman, 1976:51).

The analysis was conducted using ten predictors:

(1) course,

(2) UGPA,

(3) age entering AFIT,

(4) military academy (yes/no),

(5) undergraduate degree in engineering, mathematics, or a physical science (yes/no),

(6) marital status,

(7) AFIT volunteer status,

(8) aeronautically rated or nonrated,

(9) GRE total score, and

(10) GMAT total score.

The AID summary tree for the first five splits* is presented in Figure 2, and indicates several highly interesting findings. These findings are discussed below.

(1) The first split (that which causes the greatest reduction in the unexplained variability) is on marital status. Ten single students out of a total of 32 failed to obtain a degree, whereas only 13 of 191 marrieds were nonrecipients.

(2) The fifth split (single population) was made on volunteer status. Of the 11 single students who were AFIT volunteers, none failed to obtain a degree. Thus, 10 of the 21 single nonvolunteers were nonrecipients

*Only the first five splits are presented because no additional insight was gained from splits which occurred after.

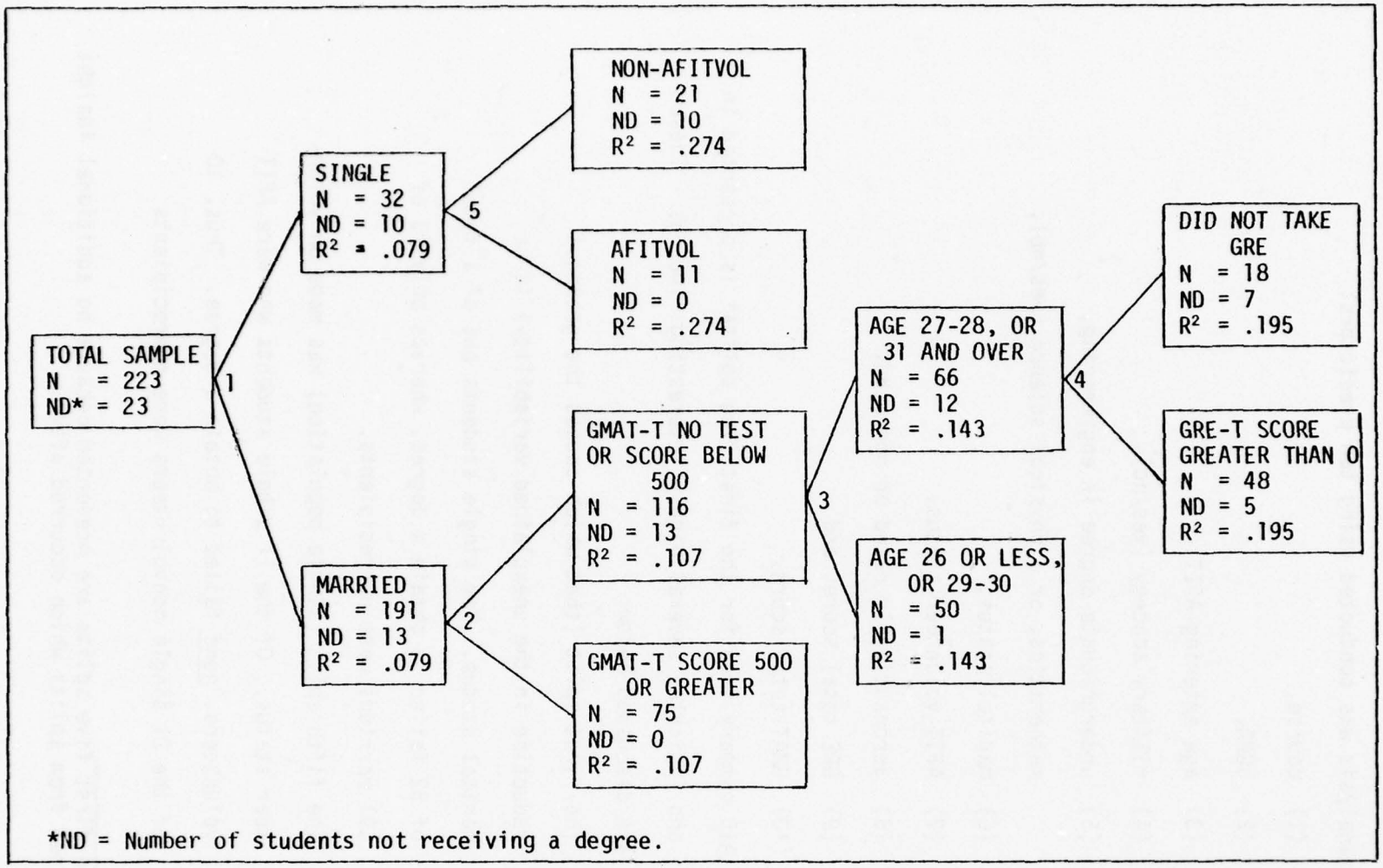


Figure 2. AID Summary Tree for Degree Receipt/Nonreceipt Prediction

making their probability of degree nonreceipt .4762, or nearly 50 percent. Compared to the probability of no degree for the rest of the population (13 ÷ 202 = .0644), this makes the single nonvolunteer group 7.4 times as likely to not receive a degree. This interaction between single and nonvolunteer status prompted the creation of a new predictor variable, single nonvolunteer, for the discriminant analysis.

(3) The married population was split second and on GMAT-T score. Interestingly, there were no married students who took the GMAT and met or exceeded the 500 point eligibility criterion that failed to attain a degree. All the married students who did not graduate either scored below 500 on the GMAT or did not take it at all. Additionally, a later split on GRE-T caused a division based only on whether a student did or did not take the GRE. These two splits caused speculation as to whether the act of taking a test could be even more significant than the scores achieved by these subjects. Therefore, two new predictor variables, the number of tests taken and whether or not a test was taken at all, were created. These variables, like volunteer status, are considered to be additional surrogate measures of motivation. The number of test taken variable further provides three levels as indicated in Table VII.

TABLE VII

Number of Entry Tests and Motivational Level

| Number of Tests | Motivation |
|---|---|
| 0 | Low |
| 1 | Moderate |
| 2 | High |

The interpretation of the AID run resulted in the creation of three new predictors, single nonvolunteer, whether or not a test was taken, and number of entry tests taken. In the next section of this chapter, the results of the discriminant analysis with these new variables included are presented.

Degree Receipt/Nonreceipt Prediction With Discriminant Analysis

This section represents the culmination of the research performed for this thesis. In it is presented the results of the final computer runs that were performed using all the predictor variables thought to potentially provide the greatest degree of predictive power. Six predictors were used: (1) student was or was not a single nonvolunteer, (2) age, (3) time since receipt of undergraduate degree, (4) whether or not an entry test was taken, (5) UGPA, and (6) number of entry examinations taken.

There are two parts to this section. The first deals with the results of the discriminant analysis using the entire subject population (N = 223, degree nonrecipients = 23). Because the outcomes were nearly identical with the prior probability of group membership based on either

size or equal chance, only one set of results, that based on size, is discussed. The second part provides an analysis of the output of the run made using equal sized no-degree (N = 23) and randomly selected degree receipient (N = 23) groups.

Discriminant Results with N = 223. A summary table for the stepwise discriminant analysis based on the maximum Mahalonobis distance criterion is provided in Table VIII. It should be stated that the stepwise solution "...is only optimal (rather than maximal) because not every possible subset is considered. The assumption is that the stepwise procedure is an efficient way of approximately locating the best set of discriminating variables." (Nie, et al., 1975:448)

TABLE VIII

*Discriminant Analysis Summary* (N = 223)

| Predictor | Partial F | Wilks' Lambda | Signifi-cance | Change in RAO's V | Signifi-cance |
|---|---|---|---|---|---|
| Single nonvolunteer | 40.97 | .844 | .000 | 40.97 | .000 |
| Took at least one test | 10.39 | .806 | .000 | 12.37 | .000 |
| Age | 3.51 | .793 | .000 | 4.40 | .036 |

A brief description of the column meanings is provided here to aid in the interpretation of the table. The partial F value is used to "...test for the statistical significance of the amount of centroid separation added by this variable above and beyond the separation produced by the previously entered variables." (Nie, et al., 1975:453). The Wilks' Lambda statistic is used to measure the overall separation based on the

variables in the equation at each step, and an approximate F test of significance is provided (Nie, et al., 1975:447,463). The Rao's V statistic is a generalized distance measure that provides the greatest overall separation of the groups based on that variable which contributes the largest V increase when added to the previous variables (Nie, et al., 1975:448,463). The test of significance of the change in V is performed using the $\chi^2$ statistic (Nie, et al., 1975:448).

Additionally, the standardized discriminant function coefficients are given in Table IX. The standardized form is used because

> "...each coefficient represents the relative contribution of its associated variable to that function. The sign merely denotes whether the variable is making a positive or negative contribution." (Nie, et al., 1975:443).

TABLE IX

Standardized Discriminant Function Coefficients (N = 223)

| Predictor | Degree Receipt Function Coefficient |
|---|---|
| Single nonvolunteer | -.976 |
| Took at least one test | .502 |
| Age | -.287 |

The implications of these results are tremendous. The selection criteria used by AFIT Admissions truncates from the population those students who scored poorly on the GRE or GMAT and whose UGPA was not fairly close to the 2.5 minimum or higher. The fact that no ability measures were used to predict degree receipt or nonreceipt indicates that the ability measures used by AFIT are appropriate but not sufficient for

predicting success. The biographic and, especially, the motivational predictors which were selected are also important. The first variable entered indicates a highly negative relationship between degree receipt and single nonvolunteer status. The degree group contains only 5.5 percent single nonvolunteers, whereas 43.5 percent of the no-degree group are single nonvolunteers, and the difference between the means was found to be highly significant. The "took at least one test" variable shows a positive relationship with degree receipt. Of the "success" group, 89 percent took at least one test while only 60.9 percent of the "failures" accomplished the same. Again, the difference between the means was found to be very significant. Age is negatively related to degree receipt, but the difference between the means is not significant when age is used alone. The interaction between volunteer status, whether a test was taken, and age must be considered for age to be a meaningful predictor. The test used to determine the significance of mean differences is described in Appendix D, and the results for all the predictors examined are presented.

The predictive power of the three variables can be better visualized by referring to the classification results table (Nie, et al., 1975:457), Table X. This table shows the percentages of students correctly classified into each group.

Most noteworthy is the fact that 43.5 percent of the degree nonrecipients were identified, yet only 5.5 percent of the successful students were done the "injustice" of being identified as "failures." It could be argued that simply predicting success for all students meeting the eligibility criteria would have resulted in an 89.7 percent (200 success

TABLE X

Classification Results Table (N = 223)

| | Predicted Degree Receipt | Predicted Degree Nonreceipt |
|---|---|---|
| Actual Degree Receipt | 94.5% | 5.5% |
| Actual Degree Nonreceipt | 56.5% | 43.5% |
| Overall 89.2% Correctly Classified | | |

divided by 223 total) correct classification, but this does nothing toward reducing the number of nonsuccessful students, the stated purpose of this study. However, to further investigate the power of motivational predictors, one final computer run with equal populations was accomplished and is reported on in the next part of this section.

Discriminant Results with N = 46. The total sample consisted of the 23 degree nonrecipients and 23 randomly selected degree recipients so that predicting success for this entire group would result in a correct classification of only 50 percent. The results of the discriminant analysis are shown in Table XI.

TABLE XI

Discriminant Analysis Results (N = 46)

| Predictor | Standardized Discriminant Function Coefficient | Partial F | Wilks' Lambda (Significance) | Change in RAO's V (Significance) |
|---|---|---|---|---|
| # of Tests Taken | .694 | 4.91 | .900 (.032) | 4.91 (.027) |

The number of tests taken has a positive relationship with degree receipt and indicates that, again, success is predicted based on a surrogate motivational measure. The results of the significance tests for group mean differences are provided in Appendix D, and indicate that the number of tests taken is a significant predictor.

The classification results are presented in Table XII. The overall correct classification of students is 60.9 percent, a 10.9 percent gain over that obtained by identifying all 46 students as degree recipients, and a noteworthy increase considering that only one predictor is utilized for classification.

TABLE XII

Classification Results Table (N = 46)

| | Predicted Degree Receipt | Predicted Degree Nonreceipt |
|---|---|---|
| Actual Degree Receipt | 82.6% | 17.4% |
| Actual Degree Nonreceipt | 60.9% | 39.1% |
| Overall 60.9% Correctly Classified | | |

The classification percentages within the table are noticeably different from those using the entire population, but this is to be expected because the characteristics of the randomly selected successes are not identical to those of the entire population. What is important is the fact that 39.1 percent of the degree nonrecipients were identified using a motivational predictor as were those employed for the total population while misclassifying only 17.4 percent of the successes, and with a 10.9 percent improvement over pure chance categorization.

## Summary

This chapter has provided the results of the analyses conducted. Three topics were discussed: (1) GGPA prediction with multivariate regression analysis, and degree receipt/nonreceipt prediction with (2) AID and (3) discriminant analysis.

The fourth and final chapter presents the conclusions arrived at and recommendations made.

# IV. CONCLUSIONS AND RECOMMENDATIONS

This research was conducted to investigate the prediction of success among Systems Management and Operations Research Master's degree students. A total population of 223 male USAF officers who attended AFIT from 1971 through 1976 was analyzed. Graduate GPA prediction was investigated using multivariate regression analysis, and success based on degree receipt or nonreceipt was examined through the application of the Automatic Interaction Detection algorithm and discriminant analysis. Based on the results of the study, the conclusions arrived at and recommendations which are made are presented below. The list of abbreviations provided in Appendix A will aid in the interpretation of this chapter.

Conclusion 1. Decreasing the homogeneity of the group, that is, combining students majoring in different fields of study, decreases the GGPA predictive power of the independent variables.

Recommendation 1. Students in different disciplines should not be combined for GGPA predictive purposes.

Conclusion 2. For the combined population of the 50 GSM and GOR students who took both the GRE and the GMAT, the GMAT quantitative score proved to be the best predictor of GGPA of all the variables examined by far.

Recommendation 2. Consideration should be given to the use of the GMAT for the satisfaction of eligibility requirements provided GGPA prediction is the criterion of success which is used.

Conclusion 3. Even when GGPA prediction is undertaken using groups with a high degree of homogeneity, the amount of predictive power

achieved is modest. Thus, the use of GGPA as a criterion is of limited value, and in fact does not necessarily determine the successful completion of a graduate program by a student.

Recommendation 3. The use of a more meaningful success criterion than GGPA is recommended. The dichotomous degree receipt/nonreceipt criterion provides an excellent measure of success.

Conclusion 4. The measures of ability used by AFIT admissions (Chapter I, AFIT Eligibility Criteria) are appropriate for determining if a prospective student is capable of completing the program, but do not measure how motivated he is toward receiving his degree.

Recommendation 4. AFIT Admissions should continue to use the traditional ability measures as eligibility criteria, but should further consider surrogate motivational measures as an aid in determining if appropriate action could reduce the "failure" rate. Suggested measures and actions are presented in the following paragraphs.

Conclusion 5. The best predictor of degree nonreceipt is single nonvolunteer status, nonvolunteer being a surrogate measure of motivation.

Recommendation 5. An intrinsically motivated student is more likely to succeed than one with equal ability but little determination. Intrinsic motivation can be heightened through proper extrinsic methods, and this approach was used in determining the two recommendations that follow:

(a) The nonvolunteer population could be reduced by increasing the AFIT recruitment effort. Many Air Force officers are not aware of the numerous AFIT programs available and the advantages that an advanced degree can provide. It is

recognized that additional funds would be required for this effort, but the savings in on-the-job man-hours lost for only one or two students who attended AFIT merely because they were centrally identified, lacked motivation, and did not receive a degree could offset the additional costs.

(b) Members of the single nonvolunteer (centrally identified) group could be further examined for degree of motivation. This could be accomplished by letter, telephone, or personal interview (possibly through the prospective student's Base Education Office). A possible format is: (1) congratulate him on his selection, (2) describe the good and bad aspects of the program, (3) inform him of the advantages of program completion, (4) warn him of the potential consequences of "failure," (5) assure him that there is absolutely no stigma attached to declining the educational opportunity, and (6) have him verify that he has a strong desire to obtain the degree. In this way the fact that the single nonvolunteer is 7.4 times more likely than all other students to not receive a degree need never be mentioned.

Conclusion 6. Whether or not a prospective student took a graduate aptitude test, like volunteer status, is a surrogate measure of motivation, and is positively related to degree attainment.

Recommendation 6. Practically all of the students centrally identified by the supplemental boards (Appendix B) do not have adequate time to take the GRE or GMAT, and thus can accept the nominations with no effort

on the students' part. Volunteers and "first round" centrally identified students must take one of the two tests before their acceptance is finalized. Increasing the number of students selected for AFIT further above the quota than is presently practiced and placing the additional selectees on the "alternate" list would have two advantages. First, a greater number of selected potential AFIT students would be required, at their own expense and on their own time, to take the GRE or GMAT. Second, the supplemental boards would be required to select fewer students, or would not have to meet at all. Those excess alternate selectees who meet the eligibility requirements could be assured of being primary during the next selection cycle.

Suggestions for Further Research

This study has blended together statistical analysis and behavioral science in an effort to predict academic success, and the results achieved suggest several interesting possibilities for further investigation.

The measurement of motivation in a civilian institution for inclusion as success predictors presents some novel, but not insurmountable, problems. Several possible measures could be examined: (1) Is the student paying his own way through college? (2) Is he on a scholarship? (3) Does he have well established career intentions for which the degree is essential?

Further validation of the findings presented in this thesis would also be worthwhile if applied to widely differing fields of study such as Physical Education, Psychology, and Nuclear Physics.

Looking Back--and Ahead

This study was performed through the use of several concepts rarely combined for a task as seemingly mundane as predicting academic success. However, wherever people are involved the inherent uncertainties necessitate scrutiny from as many vantage points as possible.

If the number of nonsuccessful students is in fact reduced through the implementation of the recommendations presented, the goal of this research has been achieved.

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# APPENDIX A

## List of Abbreviations

## APPENDIX A

### List of Abbreviations

AERORATED - possess a USAF aeronautical rating (pilot, navigator, etc.)

AFIT - Air Force Institute of Technology

AFITVOL - volunteer for AFIT

AFSC - Air Force Specialty Code

AGE - age at AFIT entry

AID - Automatic Interaction Detection algorithm

GGPA - graduate grade point average

GMAT - Graduate Management Admission Test

GMAT-Q - GMAT quantitative score

GMAT-T - GMAT total score

GMAT-V - GMAT verbal score

GOR - AFIT graduate Operations Research program

GPA - grade point average

GRADTIME - time since receipt of Bachelor's degree

GRE - Graduate Record Examination

GRE-Q - GRE quantitative score

GRE-T - GRE total score

GRE-V - GRE verbal score

GSM - AFIT Graduate Systems Management program

MILACAD - attended Annapolis, West Point, or the USAF Academy

MPC - USAF Military Personnel Center

SIE - self-initiated elimination

SINGLE NONVOL - unmarried nonvolunteer for AFIT

SPSS - Statistical Package for the Social Sciences

TEST - a compromise aptitude percentile score based on either the GMAT score, the GRE score, or the average of the two if both tests were taken

TEST-Q - TEST quantitative score

TEST-T - the sum of the TEST-Q and TEST-V scores

TEST-V - TEST verbal score

U-DEGREE - undergraduate degree not in engineering, mathematics, or a physical science

UGPA - undergraduate grade point average

# APPENDIX B

## USAF Advanced Academic Degree Management System

## APPENDIX B

### USAF Advanced Academic Degree Management System

The process begins at the Headquarters, USAF Office of the Deputy for Personnel with a determination by Air Force Specialty Code (AFSC) of the number of people required to fill forecasted quotas. From the AFSC's identified educational requirements are determined and the number of students to be selected for each AFIT course of study is set. Among this number are the sizes for each GOR and GSM Master's degree class for a given fiscal year.

Next, those officers suitable for AFIT educational programs based on academic background, quality of military record, and compatibility of the program with the officer's career progression pattern are selected at the USAF Military Personnel Center (MPC) or by the AFIT Director of Admissions from his personnel file, and are termed "centrally identified." These officers must also be available for reassignment. The availability requirement is two years minimum since last permanent change of station, or completing a controlled tour of duty, as applicable. Officers with aeronautical ratings must have additionally completed five years of rated duty.

Eligibility for AFIT is determined by the AFIT Directorate of Admissions. Volunteers and centrally identified personnel must meet three requirements:

(1) an undergraduate cumulative GPA of at least 2.5/4.0

(2) a minimum score of 500 on the GMAT total or on both the GRE-V and GRE-Q

(3) previous experience which indicates an ability to affectively learn and use the AFIT education for the good of the Air Force.

Tradeoffs between these requirements are permitted as described in Chapter I. Of the volunteers, approximately 25 percent are deemed elibible, while only eight percent eligibility is common for centrally identified officers (Lillie, 1977).

After those candidates who are eligible are determined, MPC is notified. The list of eligibles is then considered by a Resource Manager Team which consists of representatives for each potentially gaining and losing AFSC. Each eligible is voted on using a yes/no basis until the quota is overfilled by up to approximately 35 percent or the list of candidates is expended. The overfill is used in an attempt to fill quotas if eligibles are not ultimately selected for AFIT or decline the nomination.

The eligibles approved by the Resource Manager Team are then considered by the AFIT Selection Board at MPC. The Board consists of three colonels: the Chief of the Rated Officer Assignments Branch, the Chief of the Support Officer Assignments Branch, and the Deputy Chief of the Utilization Policy Division. In considering each eligible they review Career Briefs and Selection Folders to determine:

(1) promotability

(2) utilization following AFIT education

(3) how to resolve differences of opinion between Resource Managers, if necessary.

Again a yes/no vote is taken, and those candidates receiving at least two "yes" votes become selectees, subject to the approval of the USAF Deputy Chief of Staff for Military Personnel.

Approved selectees are then notified and either accept or decline the nomination. If the number of selectees accepting falls below the quota, supplemental boards are held to identify additional selectees. In this case it is frequently necessary for AFIT Admissions to determine the eligibility of candidates using no GRE or GMAT input because the candidate has had insufficient time to take the examination. Additionally, the selectee is under a great deal of pressure to rapidly make a decision which could have a tremendous impact on the remainder of his Air Force career.

After acceptance or rejection is received by MPC from the supplemental selectees, the AFIT selection process for a given fiscal year is complete.*

*All the information in this appendix was provided in March 1977 by Lt Col Gerald C. Malicki of the AFIT Directorate of Admissions except where referenced otherwise.

# APPENDIX C

## Bivariate Correlation Matrices

Correlation Matrix for the Total Sample Less SIE's (Level I, Group 1)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| UGPA | .170 | | | | | | | |
| AGE | -.053 | .082 | | | | | | |
| GRADTIME | -.057 | -.061 | .736 | | | | | |
| MILACAD | -.098 | -.100 | -.043 | .164 | | | | |
| U-DEGREE | -.118 | .058 | -.112 | -.135 | .229 | | | |
| SINGLE | -.047 | .003 | -.258 | -.243 | .016 | .061 | | |
| AFITVOL | .146 | .039 | .069 | -.053 | -.067 | -.021 | -.077 | |
| AERORATED | -.027 | -.010 | .334 | .415 | .449 | .035 | -.203 | -.085 |
| | GGPA | UGPA | AGE | GRADTIME | MILACAD | U-DEGREE | SINGLE | AFITVOL |

Correlation Matrix for All Entry Test Takers Less SIE's (Level II, Group 1)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UGPA | .173 | | | | | | | | | | |
| AGE | .004 | .091 | | | | | | | | | |
| GRADTIME | -.016 | -.066 | .686 | | | | | | | | |
| MILACAD | -.100 | -.105 | -.089 | .157 | | | | | | | |
| U-DEGREE | -.127 | .059 | -.113 | -.135 | .199 | | | | | | |
| SINGLE | -.021 | -.039 | -.307 | -.276 | .003 | .053 | | | | | |
| AFITVOL | .147 | .057 | .072 | -.068 | -.121 | -.059 | -.038 | | | | |
| AERORATED | -.006 | -.009 | .295 | .385 | .482 | -.063 | -.210 | -.106 | | | |
| TEST-V | .141 | .025 | .153 | .223 | .068 | .088 | -.008 | .053 | .064 | | |
| TEST-Q | .230 | .117 | -.083 | .030 | .198 | .000 | .017 | .020 | .067 | .183 | |
| TEST-T | .234 | .085 | .063 | .178 | .163 | .064 | .004 | .049 | .085 | .826 | .705 |
| | GGPA | UGPA | AGE | GRAD-TIME | MILACAD | U-DEGREE | SINGLE | AFIT-VOL | AERO-RATED | TEST-V | TEST-Q |

Correlation Matrix for All GSM Entry Test Takers Less SIE's (Level III, Group 1)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UGPA | .271 | | | | | | | | | | |
| AGE | .071 | .177 | | | | | | | | | |
| GRADTIME | .022 | .029 | .691 | | | | | | | | |
| MILACAD | -.132 | -.040 | -.109 | .093 | | | | | | | |
| U-DEGREE | -.050 | .134 | -.156 | -.146 | .294 | | | | | | |
| SINGLE | -.013 | -.067 | -.266 | -.295 | -.039 | .052 | | | | | |
| AFITVOL | .071 | .097 | .110 | -.032 | -.102 | -.021 | -.125 | | | | |
| AERORATED | -.043 | .134 | .258 | .280 | .405 | .230 | -.148 | -.154 | | | |
| TEST-V | .213 | -.010 | .181 | .280 | .032 | .046 | .007 | .045 | .007 | | |
| TEST-Q | .264 | .144 | -.036 | .058 | .194 | .084 | -.067 | -.018 | .034 | .250 | |
| TEST-T | .298 | .077 | -.103 | .225 | .135 | .080 | -.034 | -.020 | .024 | .827 | .751 |
| | GGPA | UGPA | AGE | GRAD-TIME | MILACAD | U-DEGREE | SINGLE | AFIT-VOL | AERO-RATED | TEST-V | TEST-Q |

Correlation Matrix for All GOR Entry Test Takers Less SIE's (Level III, Group 2)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UGPA | -.037 | | | | | | | | | | |
| AGE | -.119 | .054 | | | | | | | | | |
| GRADTIME | -.072 | -.154 | .649 | | | | | | | | |
| MILACAD | -.077 | -.295 | .004 | .342 | | | | | | | |
| U-DEGREE | -.268 | -.031 | -.050 | -.136 | .072 | | | | | | |
| SINGLE | -.044 | -.032 | -.388 | -.243 | .043 | .060 | | | | | |
| AFITVOL | .275 | -.039 | .031 | -.115 | -.173 | -.114 | .075 | | | | |
| AERORATED | .054 | -.255 | .410 | .628 | .596 | -.204 | -.303 | -.038 | | | |
| TEST-V | .038 | .130 | .074 | .098 | .147 | .146 | -.020 | .077 | .157 | | |
| TEST-Q | .119 | -.100 | -.074 | .090 | .136 | -.139 | .128 | .048 | .110 | .144 | |
| TEST-T | .091 | .051 | .020 | .123 | .186 | .044 | .050 | .085 | .180 | .862 | .625 |
| | GGPA | UGPA | AGE | GRAD-TIME | MILACAD | U-DEGREE | SINGLE | AFIT-VOL | AERO-RATED | TEST-V | TEST-Q |

Correlation Matrix for All Students Who Took Both the GRE and GMAT

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGPA | .196 | | | | | | | | | | | | |
| AGE | .044 | .110 | | | | | | | | | | | |
| MILACAD | .005 | -.242 | -.179 | | | | | | | | | | |
| U-DEGREE | -.106 | .001 | -.098 | .286 | | | | | | | | | |
| SINGLE | .007 | -.365 | -.134 | -.005 | | | | | | | | | |
| AFITVOL | .050 | .132 | .109 | -.127 | .029 | -.092 | | | | | | | |
| AERORATED | -.092 | .028 | .439 | .447 | -.002 | -.402 | .101 | | | | | | |
| GRE-V | .187 | .081 | .019 | .132 | .168 | .213 | .194 | .013 | | | | | |
| GRE-Q | .221 | .027 | .014 | .094 | -.052 | .152 | -.012 | -.038 | .313 | | | | |
| GRE-T | .241 | .080 | .066 | .133 | .091 | .224 | .149 | -.028 | .872 | .669 | | | |
| GMAT-V | .288 | .058 | .144 | .252 | .213 | .269 | .137 | .083 | .783 | .293 | .723 | | |
| GMAT-Q | .437 | .164 | -.030 | -.031 | -.061 | .228 | -.065 | -.204 | .433 | 593 | .618 | .527 | |
| GMAT-T | .325 | .079 | .145 | .149 | .122 | .222 | .094 | -.025 | .768 | .463 | .826 | .890 | .759 |
| | GGPA | UGPA | AGE | MILACAD | U-DEGREE | SINGLE | AFIT-VOL | AERO-RATED | GRE-V | GRE-Q | GRE-T | GMAT-V | GMAT-Q |

# APPENDIX D

## The t Test for Differences Between Means

APPENDIX D

## The t Test for Differences Between Means*

Question: Are the differences between sample means statistically significant?

$H_0 : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

$\mu$ = true mean

At a level of significance of .05, reject $H_0$ if $t > t_{.05,\ n_1 + n_2 - 2}$

where $$t = \frac{\bar{x}_1 - \bar{x}_2 - 0}{\sqrt{\frac{(n_1 - 1)\ s_1^2 + (n_2 - 1)\ s_2^2}{n_1 + n_2 - 2}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

and $x_i$ = sample mean; $i^{th}$ sample, i = 1, 2

$s_i^2$ = sample variance; $i^{th}$ sample, i = 1, 2

$n_i$ = sample size; $i^{th}$ sample, i = 1, 2

Caveat: This test evaluates the significance of the difference between means for the variable taken alone. The discriminant analysis significance tests consider the significance of a variable in conjunction with all variables previously entered into the analysis. Thus, predictor group mean differences could fail to achieve significance using this test, and yet be significant in the discriminant function.

*Adapted from Freund, 1971:318-320

Tests Based on the Total Population

(1) Single Nonvolunteer Group Mean Difference Test (N = 223)

$\bar{x}_1 = .435$ $\quad H_o : \mu_1 - \mu_2 = 0$

$\bar{x}_2 = .055$ $\quad H_a : \mu_1 - \mu_2 > 0$

$s_1^2 = .257$ $\quad$ Reject $H_o$ if $t > 1.645$

$s_2^2 = .052$

$n_1 = 23$

$n_2 = 200$

$t_{.05,221} = 1.645$

$$t = \frac{.435 - .055 - 0}{\sqrt{\frac{(22)(.257) + (199)(.052)}{221}}\sqrt{\frac{1}{23} + \frac{1}{200}}}$$

$t = 6.413 > 1.645$, therefore reject $H_o$

The Means are Different

(2) Took at Least One Test Group Mean Difference Test (N=223)

$\bar{x}_1 = .890$ $\quad H_o : \mu_1 - \mu_2 = 0$

$\bar{x}_2 = .609$ $\quad H_a : \mu_1 - \mu_2 \quad 0$

$s_1^2 = .098$ $\quad$ Reject $H_o$ if $t > 1.645$

$s_2^2 = .249$

$n_1 = 200$

$n_2 = 23$

$t_{.05,221} = 1.645$

$$t = \frac{.890 - .609 - 0}{\sqrt{\frac{(199)(.098) + (22)(.249)}{221}}\sqrt{\frac{1}{200} + \frac{1}{23}}}$$

$t = 3.799 > 1.645$, therefore reject $H_o$ The means are different

The remaining t test results provided below were computed using the same techniques employed previously.

(3) Age Group Mean Difference Test (N = 223)

$\bar{x}_1 = 30.31$

$\bar{x}_2 = 30.30$

$s_1^2 = 12.89$

$s_1^2 = 16.22$

$n_1 = 200$

$n_2 = 23$

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.645$

$t = .013$

Cannot say that the means are different

(4) Time Since Receipt of Undergraduate Degree Group Mean Difference Test (N = 223)

$\bar{x}_1 = 7.06$

$\bar{x}_2 = 6.87$

$s_1^2 = 10.05$

$s_2^2 = 12.94$

$n_1 = 200$

$n_2 = 23$

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.645$

$t = .269$

Cannot say that the means are different

(5) Number of Tests Taken Group Mean Difference Test (N = 223)

$\bar{x}_1 = 1.130$

$\bar{x}_2 = .696$

$s_1^2 = .335$

$s_2^2 = .403$

$n_1 = 200$

$n_2 = 23$

$t_{.05,221} = 1.645$

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

$t = 3.371$

The means are different

(6) UGPA Group Mean Difference Test (N = 223)

$\bar{x}_1 = 2.964$

$\bar{x}_2 = 2.888$

$s_1^2 = .110$

$s_2^2 = .161$

$n_1 = 200$

$n_2 = 23$

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.645$

$t = 1.018$

Cannot say that the means are different.

## Tests Based on the Reduced Population

### (1) Number of Tests Taken Group Mean Difference Test (N = 46)

$\bar{x}_1$ =

$\bar{x}_2$ =

$s_1^2$ =

$s_2^2$ =

$n_1 = n_2 = 23$

(Group 1 = "success")

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.681$

$t = 2.212$

The means are different

### (2) Single Nonvolunteer Group Mean Difference Test (N = 46)

$\bar{x}_1 = .435$

$\bar{x}_2 = .217$

$s_1^2 = .257$

$s_2^2 = .178$

$n_1 = n_2 = 23$

(Group 1 = "failure")

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.681$

$t = 1.585$

Cannot say that the means are different

### (3) Age Group Mean Difference Test (N = 46)

$\bar{x}_1 = 30.304$

$\bar{x}_2 = 29.826$

$s_1^2 = 16.221$

$s_2^2 = 17.059$

$n_1 = n_2 = 23$

(Group 1 = "failure")

$H_o : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_o$ if $t > 1.681$

$t = .397$

Cannot say that the means are different

(4) Time Since Receipt of Undergraduate Degree Group Mean Difference Test (N = 46)

$\bar{x}_1 = 6.870$

$\bar{x}_2 = 6.087$

$s_1^2 = 12.937$

$s_2^2 = 11.265$

$n_1 = n_2 = 23$

(Group 1 = "failure")

$H_0 : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_0$ if $t > 1.681$

$t = .763$

Cannot say that the means are different

(5) UGPA Group Mean Difference Test (N = 46)

$\bar{x}_1 = 2.920$

$\bar{x}_2 = 2.888$

$s_1^2 = .063$

$s_2^2 = .161$

$n_1 = n_2 = 23$

(Group 1 = "success")

$H_0 : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_0$ if $t > 1.681$

$t = .324$

Cannot say that the means are different

(6) Took at Least One Test Group Mean Difference Test (N = 46)

$\bar{x}_1 = .826$

$\bar{x}_2 = .609$

$s_1^2 = .150$

$s_2^2 = .249$

$n_1 = n_2 = 23$

(Group 1 = "success")

$H_0 : \mu_1 - \mu_2 = 0$

$H_a : \mu_1 - \mu_2 > 0$

Reject $H_0$ if $t > 1.681$

$t = 1.647$

Cannot say that the means are different

# VITA

Robert W. Keith was born in Newark, New Jersey on May 14, 1943. He graduated from high school in Rockaway, New Jersey in 1960 and attended the Georgia Institute of Technology from which he graduated in 1964 with a Bachelor's degree in Mechanical Engineering and a commission in the United States Air Force.

After completing pilot training at Moody Air Force Base, Georgia, he operationally flew the F-101 at Suffolk County Air Force Base, New York, the A-1 in Southeast Asia, and the F-101 and, later, the F-106 at Grand Forks Air Force Base, North Dakota.

During 1973 he attended the United States Air Force Test Pilot School at Edwards Air Force Base, California. After graduation he worked as an experimental test pilot at Kelly Air Force Base, Texas flying the F-106, F-5, and T-38 aircraft. He entered the Air Force Institute of Technology in June 1976.

He is married to the former N. Jean Smith of Atlanta, Georgia. They have two sons, Robert and Bradley.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This research was conducted to investigate the prediction of success among Systems Management and Operations Research Master's degree students. A total population of 223 male United States Air Force (USAF) officers who attended AFIT from 1971 through 1976 was analyzed.

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Graduate grade point average (GGPA) prediction was investigated using multivariate regression analysis, and success based on degree receipt or nonreceipt was examined through the application of the Automated Interaction Detection algorithm and discriminant analysis. The predictor variables examined included not only ability and biographical data, but several surrogate measures of motivation toward degree achievement as well.

The results of the GGPA study confirmed the findings of previous researchers that students in different disciplines should not be combined for GGPA predictive purposes, and also indicated that the GGPA predictive power attainable is modest. Additionally, the use of GGPA as a criterion of academic success is of questionable value. Most significant was the finding that student selection criteria truncate from the population those persons who lack the ability to achieve a degree, and that the motivational measures were the best predictors of degree receipt.